

Special Report  
CMU/SEI-96-SR-003



Carnegie-Mellon University  
Software Engineering Institute

## CMM<sup>sm</sup> Version 1.1 Measurement Map

Robert E. Park

October 1996

19961202 077

**DISTRIBUTION STATEMENT A**  
Approved for public release  
Distribution Unlimited

Carnegie Mellon University does not discriminate and Carnegie Mellon University is required not to discriminate in admission, employment, or administration of its programs or activities on the basis of race, color, national origin, sex or handicap in violation of Title VI of the Civil Rights Act of 1964, Title IX of the Educational Amendments of 1972 and Section 504 of the Rehabilitation Act of 1973 or other federal, state, or local laws or executive orders.

In addition, Carnegie Mellon University does not discriminate in admission, employment or administration of its programs on the basis of religion, creed, ancestry, belief, age, veteran status, sexual orientation or in violation of federal, state, or local laws or executive orders. However, in the judgment of the Carnegie Mellon Human Relations Commission, the Department of Defense policy of, "Don't ask, don't tell, don't pursue," excludes openly gay, lesbian and bisexual students from receiving ROTC scholarships or serving in the military. Nevertheless, all ROTC classes at Carnegie Mellon University are available to all students.

Inquiries concerning application of these statements should be directed to the Provost, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213, telephone (412) 268-6684 or the Vice President for Enrollment, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213, telephone (412) 268-2056.

Obtain general information about Carnegie Mellon University by calling (412) 268-2000.

**Special Report**  
CMU/SEI-96-SR-003  
October 1996

## **CMM<sup>sm</sup> Version 1.1 Measurement Map**



**Robert E. Park**

Software Engineering Measurement and Analysis

Unlimited distribution subject to the copyright

**Software Engineering Institute**  
Carnegie Mellon University  
Pittsburgh, PA 15213

ITIC QUALITY INSPECTED 4

This report was prepared for the

SEI Joint Program Office  
HQ ESC/AXS  
5 Eglin Street  
Hanscom AFB, MA 01731-2116

The ideas and findings in this report should not be construed as an official DoD position. It is published in the interest of scientific and technical information exchange.

FOR THE COMMANDER



Thomas R. Miller, Lt Col, USAF  
SEI Joint Program Office

This work is sponsored by the U.S. Department of Defense.

Copyright © 1996 by Carnegie Mellon University.

Permission to reproduce this document and to prepare derivative works from this document for internal use is granted, provided the copyright and "No Warranty" statements are included with all reproductions and derivative works.

Requests for permission to reproduce this document or to prepare derivative works of this document for external and commercial use should be addressed to the SEI Licensing Agent.

#### NO WARRANTY

THIS CARNEGIE MELLON UNIVERSITY AND SOFTWARE ENGINEERING INSTITUTE MATERIAL IS FURNISHED ON AN "AS-IS" BASIS. CARNEGIE MELLON UNIVERSITY MAKES NO WARRANTIES OF ANY KIND, EITHER EXPRESSED OR IMPLIED, AS TO ANY MATTER INCLUDING, BUT NOT LIMITED TO, WARRANTY OF FITNESS FOR PURPOSE OR MERCHANTABILITY, EXCLUSIVITY, OR RESULTS OBTAINED FROM USE OF THE MATERIAL. CARNEGIE MELLON UNIVERSITY DOES NOT MAKE ANY WARRANTY OF ANY KIND WITH RESPECT TO FREEDOM FROM PATENT, TRADEMARK, OR COPYRIGHT INFRINGEMENT.

This work was created in the performance of Federal Government Contract Number F19628-95-C-0003 with Carnegie Mellon University for the operation of the Software Engineering Institute, a federally funded research and development center. The Government of the United States has a royalty-free government-purpose license to use, duplicate, or disclose the work, in whole or in part and in any manner, and to have or permit others to do so, for government purposes pursuant to the copyright license under the clause at 52.227-7013.

This document is available through Research Access, Inc., 800 Vinial Street, Pittsburgh, PA 15212.  
Phone: 1-800-685-6510. FAX: (412) 321-2994. RAI also maintains a World Wide Web home page. The URL is <http://www.rai.com>

Copies of this document are available through the National Technical Information Service (NTIS). For information on ordering, please contact NTIS directly: National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161. Phone: (703) 487-4600.

This document is also available through the Defense Technical Information Center (DTIC). DTIC provides access to and transfer of scientific and technical information for DoD personnel, DoD contractors and potential contractors, and other U.S. Government agency personnel and their contractors. To obtain a copy, please contact DTIC directly: Defense Technical Information Center, Attn: FDRA, Cameron Station, Alexandria, VA 22304-6145. Phone: (703) 274-7633.

Use of any trademarks in this report is not intended in any way to infringe on the rights of the trademark holder.

# Table of Contents

<b>1</b>	<b>Overview</b>	<b>1</b>
	Genesis and Structure	1
	Prerequisites	2
	Objectives	2
	Current Applications	2
	Improving the CMM	2
<b>2</b>	<b>The Measurement Map</b>	<b>5</b>
	Format and Notation	5
	The CMM's View of Software Measurement	6
	Part 1: The Software Process—Measures and Things to Be Measured	7
	Part 2: Key Process Areas and Activities	22
	Part 3: The Software Process Database	49
	<b>References</b>	<b>53</b>



# CMM v1.1 Measurement Map

**Abstract:** This report identifies and tabulates all references to software measures and measurement activities that appear in Version 1.1 of the Capability Maturity Model<sup>sm</sup> for Software (CMM<sup>sm</sup>). Each reference is listed in a structured format, and the results are sorted into topic areas in a way that is designed to help organizations plan the evolution of their measurement activities across the key process areas of the CMM. Where the CMM's guidance is unclear or incomplete, opportunities for improving the CMM are noted and explained.

## 1 Overview

### Genesis and Structure

This report is the result of the author's attempt to identify all references to software measures and measurement activities that occur in Version 1.1 of the Capability Maturity Model for Software (CMM) [Paulk 93a, 93b, 95]. It presents a table that sorts the CMM's statements with respect to measurement into related topics and maps the sequencing of measurement activities across the levels of the CMM. The measurement map is presented in three parts, as follows:

Part 1—The Software Process: Measures and Things To Be Measured (Measures and activities associated with the software process itself)	Pages 7–21
Part 2—Key Process Areas and Activities (Measures and activities related to individual key process areas of the CMM)	Pages 22–48
Part 3—The Software Process Database (Statements that the CMM makes relative to data to be saved and activities associated with the software process database)	Pages 49–52

The first page of each part lists the topics within that part of the measurement map and shows the page numbers within the map where the topics can be found.

---

<sup>sm</sup> CMM and Capability Maturity Model are service marks of Carnegie Mellon University.

## Prerequisites

Users of this report and of the measurement map are presumed to have a basic familiarity with the CMM.

## Objectives

The measurement map of the CMM was prepared with the following objectives in mind:

1. Consolidate and organize the guidance that the CMM provides with respect to software measurement.
2. Provide a systematic listing of measures and measurement activities that can help organizations assess the coverage and effectiveness of their software measurement practices, as they relate to the goals and key process areas of the CMM.
3. Identify and summarize the evolutionary progression of measurement activities that the CMM envisions as organizations progress to higher levels of process maturity.
4. Help organizations introduce software measures and measurement activities in ways that support a smooth progression up the maturity ladder.
5. Help practitioners identify where measures and measurement practices can be used for multiple purposes, so that economies in measurement can be achieved.
6. Identify ways in which the CMM's treatment of software measurement can be improved as the CMM evolves toward Version 2.0.

## Current Applications

One major U.S. company with multiple sites and multiple lines of business is using the CMM measurement map in this report to provide a structure for assessing the measurement practices of its various software organizations. Extracts from the map are providing the baselines against which coverage and effectiveness of local measurement activities are being evaluated. The company's first objective is to understand where each operating organization stands with respect to installing and using measures that support their planned progressions to higher maturity levels. Its second objective is to identify opportunities for improving its measurement processes and practices.

## Improving the CMM

In pulling the summary table together, numerous opportunities for improving the correctness, completeness, clarity, and consistency of the CMM's treatment of measurement and



statistical methods became apparent. These opportunities have been noted and explained in the comments within the table. The potential areas for improvement include

- making terminology, requirements, and examples of software measures and measurement activities internally consistent
- eliminating impossible or unproductive requirements and examples
- eliminating redundancies
- coordinating measures and measurement activities among key process areas, so that economies in collecting, storing, analyzing, and reporting measurement results can be achieved
- identifying closely related measures and measurement activities, so that opportunities for commonality and sharing can be exploited
- improving the evolutionary path of measurement practices across CMM maturity levels, so that measurement activities that appear useful for Levels 2 and 3 do not turn out to be counterproductive at Levels 4 and 5
- correcting errors and misunderstandings in the CMM's references to statistical methods and in its discussions of the use of control charts and statistical process control for managing and improving software processes
- improving coverage (Some important aspects related to measurement and the use of measurement results were found missing. These are identified and explained.)
- improving the clarity and correctness of the presentation and discussion of measurement issues
- providing guidelines and advice for the quantitative and operational aspects of software process databases, so that the databases may more effectively serve the estimating, planning, and process improvement needs of software organizations

The measurement map, together with and the comments and recommendations it contains, is being used as an input to the development of Version 2.0 of the CMM.



## 2 The Measurement Map

### Format and Notation

Column One of the measurement map lists the actions, measures, indicators, and requirements for measurement that are mentioned in Version 1.1 of the CMM. Bold-faced type highlights specific measures and things to be measured.

Column two identifies the locations in the CMM where the references occur (sometimes there is more than one reference). The notation used is shown below. With this notation, entries such as "PP A7.5, PR Ab3" show that the item was mentioned in Activity 7.5 of the Software Project Planning KPA and in Ability 3 of the Peer Reviews KPA.

Symbol	Key Process Area (KPA)
<u>Level 2</u>	
RM	Requirements Management
PP	Software Project Planning
PTO	Software Project Tracking and Oversight
SM	Software Subcontract Management
SQA	Software Quality Assurance
SCM	Software Configuration Management
<u>Level 3</u>	
OPF	Organizational Process Focus
OPD	Organizational Process Definition
TP	Training Program
IM	Integrated Software Management
PE	Software Product Engineering
IG	Intergroup Coordination
PR	Peer Reviews
<u>Level 4</u>	
QPM	Quantitative Process Management
QM	Software Quality Management
<u>Level 5</u>	
DP	Defect Prevention
TCM	Technology Change Management
PCM	Process Change Management

Symbol	Section of the Key Process Area
G	Goals
C	Commitment to perform
Ab	Ability to perform
A	Activities performed
M	Measurement and analysis
V	Verifying implementation

Column 3 of the measurement map contains notes, observations, clarifications, and recommendations that represent the views of the author.

Columns 4–7 identify the categories into which the measures or activities fall. The notation used is as follows:

Symbol	Category
R	A required measure or action
I	Implied by a required measure or action
T	Classified by the CMM as a typical measure or action (i.e., alternatives are permitted)
E	Cited by the CMM as an example of a representative measure or action
X	Implied by an example measure or action

Users of the measurement map should keep in mind that the CMM contains no requirements. It is purely a descriptive model, not a prescriptive one. The author's use of the term "required" in this report should be interpreted in the sense that the measure or action is required if an organization is to be considered compliant with the CMM.

## The CMM's View of Software Measurement

The measurement map is presented on the pages that follow. It consists of three parts, as shown below. The topics in each part are listed on the first page of the part.

**Part 1: The Software Process—Measures and Things to Be Measured**

**Page 7**

**Part 2: Key Process Areas and Activities**

**Page 22**

**Part 3: The Software Process Database**

**Page 49**

# **CMM v1.1 Measurement Map**

## **Part 1**

### **The Software Process: Measures and Things to Be Measured**

<b>Topic</b>	<b>Page</b>
Size	8
Complexity	9
Reuse	10
Computer Resources	10
Support Facilities	11
Effort	11
Staffing	12
Schedule	13
Cost	16
Productivity	17
Risk	18
Testing	18
Scrap and Rework	18
Quality (organizational focus)	19
Quality (project focus)	19

## CMM v1.1 Measurement Map

[illegible]

Measures and things to be measured are shown in bold face.

Page 8

**R = Required**    **I = Implied**    **T = Typical**    **E = Example**    **X = Implied by Example**

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2			Level 3			Lvl 4			Level 5		
			P	S	S	O	P	I	P	Q	P	T	P	P
			R	P	T	S	M	A	F	D	P	E	G	R
Size (actual) of generated code Size (actual) of fully tested code Size (actual) of delivered code Size (actual) for (major) software work products	PTO A5.2 PTO A5.2 PTO A5.2 PTO A5.1 OPD A5.1, IM A5.1, A5.3 PTO A5.1, A5.3 PTO A5.1, A5.3 PTO A5.3 IM A7.2 QPM A4.2	Implies periodic measurement & reporting Implies periodic measurement & reporting Implies periodic measurement & reporting  "Major" = ?? Implies periodic measurement, reporting, and review Implies periodic measurement & reporting	R R R R											
Size (actual) for changes to (major) software work products Track the above measures. Units (actual) of delivered documentation Size (of the system) (actual) Size (actual)														
A group independent of the software engineering group - reviews the procedures for estimating size (and changes to size) of software work products - provides guidance in using historical data to establish credible estimates (An example of an independent group is a software estimating group.) (An example of a method to evaluate size credibility is function-by-function comparison to a completed system.) Individuals who prepare size estimates ensure the procedures and data they use are appropriate. When the validity of a size estimate is questioned, a team of peers and experts reviews the estimate. Apply contingency factors to the size estimates for each software element identified as a software risk. Document the rationale for the contingency. Assess and document the risks associated with eliminating the contingency.	IM A6.1 IM A6.1 IM A6.1 IM A6.1 IM A6.1 IM A6.1 IM A6.2 IM A6.2 IM A6.2													

<b>Complexity</b>														
<b>Complexity (of the system)</b>	IM A7.2	Presumably data about these go into the software process database. The CMM is silent about this. Cantor's theorem suggests that no (single) real-valued measure for complexity is feasible. It is possible, though, to construct ordinal measures for specific attributes of complexity [Fenton 91, pp32-33]. The CMM should be reworded here to avoid setting an impossible standard.												
Geographic locations of the project's groups, organizations, and subcontractors Host environment (for development) Target environment The developer's familiarity with the application The developer's experience with the application Availability of resources Other special constraints	IM A7.2 IM A7.2 IM A7.2 IM A7.2 IM A7.2 IM A7.2 IM A7.2 IM A7.2	This should read "experience with the type of application," not with the application itself.												

Measures and things to be measured are shown in bold face.

R = Required I = Implied T = Typical E = Example X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level					Level				
			P	S	S	O	O	P	P	P	P	P
Reuse			R	P	T	S	Q	C	C	P	P	T
Identify off-the-shelf or reusable components. Use this information to manage size and as a basis for reuse measures. <b>Reuse measures</b> Account for reuse of requirements, design, code, test plans, & test procedures. The effort to modify and incorporate reusable components is factored into the size estimates. <b>Degree of program modification</b>	IM A6.3 IM A6.3 IM A6.3 IM A6.3 IM A6.3 TCM Ab4	Reuse measurement is closely coupled to size measurement. The CMM errs in deferring reuse measurement to Level 3. Reuse estimates and measures must be used at Level 2 for project planning and project tracking, so that size measures can be interpreted correctly.  This Level-3 information is needed for Level-2 KPAs.  This doesn't make sense! You can have size=>size, effort=> effort, or size=>effort, but not effort=>size.										

<b>Computer resources</b>												
<b>Computer memory capacity (estimated)</b>	PP A11.1	Measures for describing capacities and usages	E									
<b>Communication channel capacity (estimated)</b>	PP A11.1		E									
<b>Critical computer resource usage (estimated)</b>	PP A7.7		E									
Use a documented procedure.	PP A11		R									
Relate estimates to size of work products, operational processing load, and communications traffic.	PP A11.2		R									
Estimate usage for each major software component.	PTO A7.1											
Base estimates on historical experience, simulations, prototyping, or analysis.	IM A8.1											
Record the similarities and differences between the project and the historical data.	IM A8.1											
Record the reasoning used to judge the credibility of the estimates.	IM A8.1											
Document sources and rationales.	IM A8.1											
Document and review estimates.	PP A11.3											
Document changes that affect software commitments.	PTO A7.2											
<b>Critical computer resource usage (projected)</b>	PTO A7.1	Updated projections should be documented too. The context implies that "projected" = updated estimates.	T									
Track and compare to plan.	PTO A7.1		R									
Document changes that affect software commitments.	PTO A7.2		R									
<b>Critical computer resource usages (actual)</b>	PTO A7, A7.1											
Track and compare to plan.	PTO A7.1		R									
<b>Critical computer resources (available capacities) (actual)</b>	IM A8.3, A8.4											
<b>Critical computer resource capacities (planned)</b>	IM A8.4	Planned values can (and often do) differ from estimates. If estimating and measuring computer resources are so important to Level 2, it seems strange that the CMM defers planning for these issues until Level 3.										
<b>Critical computer resources (reserve capacities) (planned)</b>	IM A8.4											

Measures and things to be measured are shown in bold face.

R = Required I = Implied T = Typical E = Example X = Implied by Example



## CMM v1.1 Measurement Map

<i>Issue</i>	References	Notes, implied requirements, and points needing clarification	Level 2	Level 3	Lvl 4	Level 5
Action, measure, indicator, or requirement			P S S O R P T S Q C C P M P O M A M F D	O O P T I P I P D P E G R M	Q P Q D C C M P M M	T P C C C M
<b>Support Facilities</b>						
<b>Capacity requirements (estimates) for support facilities</b> Base estimates on estimated sizes of software work products. Examples of support facilities include development computers & peripherals, test computers & peripherals, target computer environment software, and support software.	PP A14.1 PP A14.1 PP A14.1		R R E			

Software effort (estimated) for the project		PP A7.6, A10, PTO A6, IM A5.3 PP A10 PP A10.3 IM A7.1 PP A10.3 PP A10.2	For productivity data to be meaningful, there must be mechanisms for normalizing productivities across differing projects and situations. This implies the need for a rationale and structure for attributing cause and effect, so that results can be related to controllable or environmental parameters. Perhaps the CMM should address this.  It is unlikely that effective estimating can ever be reduced to simple productivity numbers. The real issues here are cost model use and cost model calibration.	R R  R T T T	E  T
<p>Use a documented procedure when deriving estimates.</p> <p>Base estimates on past experience.</p> <p>Use historical data where appropriate.</p> <p>Use similar projects when possible.</p> <p>Use productivity data (historical or current).</p>	<p>Relate estimates to estimates for size of work products or changes.</p> <p>Document and review assumptions.</p> <p>Document and review estimates.</p> <p>Document effort estimates in the software development plan.</p> <p>Adapt the models used to estimate effort to the project.</p> <p>Update the parameter values of the models used in estimating software effort whenever major changes are made to the software requirements.</p> <p><b>Effort distribution (estimated) over the software life cycle</b></p> <p><b>Effort (estimated) for software work products</b></p> <p><b>Effort allocated to individually managed tasks or stages</b></p> <p><b>Effort (estimated) to modify and incorporate reusable components</b></p> <p>Factor effort into the size estimates.</p>	<p>PP A10.1 PP A10.4 PP A10.4 PTO A6.3 IM A7.1 IM A7.4  PP A10.3 OPD A5.1 IM A7.3 IM A6.3 IM A6.3  PR Ab3 PR Ab3</p>	<p>T T T  R  T</p>	<p>T    T T  E T T T</p>	<p>X X</p>
<p><b>Effort (estimated) for preparing for peer reviews</b></p> <p><b>Effort (estimated) for participating in peer reviews</b></p>	<p><b>SQA effort (planned)</b></p> <p><b>SCM effort (planned)</b></p> <p><b>Effort (planned) for process assessment</b></p> <p><b>Effort (planned) for process development and improvement</b></p> <p><b>Effort (planned) to manage the project</b></p>	<p>SQA M1 SCM M1 OPF M1 OPF M1 IM M1</p>	<p>E</p>	<p>X X</p>	<p>E</p>

Measures and things to be measured are shown in bold face.

Page 11

**R** = Required    **I** = Implied    **T** = Typical    **E** = Example    **X** = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, Indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2			Level 3			Lvl 4			Level 5			
			P R M	S P O	S Q M	O P F	O P D	P T I	P I P	P P E	Q P R	P Q M	T C P	P C M	M M
Effort expended (for planning tasks)	PP M1		E												
Effort expended in performing tracking and oversight	PTO M1														
Software effort (actual) for the project	PTO A6, A6.1, OPD A5.1 IM A5.1, A7 PTO A6.1	Implies that the work completed must also be measured and tracked. Implies periodic measurement & reporting.	R												
Track, over time, against work completed.															
Compare to plan.	PTO A6.1, A6.3		R												
SQA effort expended (actual)	SQA M1														
SCM effort expended (actual)	SCM M1														
Effort expended for process assessment	OPF M1														
Effort expended for process development and improvement	OPF M1														
Effort (actual) for software work products	OPD A5.1														
Effort (actual) to manage the project	IM M1														
Magnitude of replanning effort	IM M1														
Effort to analyze each proposed change to a requirement	PE M2														
Cumulative effort to analyze proposed changes to requirements	PE M2														
Effort (actual) expended by the software engineering group to support other engineering groups	IG M1														
Effort (actual) expended by other engineering groups to support the software engineering group	IG M1														
Rework effort resulting from peer reviews	PR A3														
Effort to fix products and processes	TCM Ab4														
Resource expenditures by project, process stage, tools & methods used, program category, degree of program modification, etc.	TCM Ab4														
Effort (estimated/revised) for remaining work	IM A5.3, A7.4														
Updated estimates use actual productivity data from the current project where appropriate.	IM A7.4														
Use a documented procedure to manage the project's software effort.	IM A7														

<b>Staffing</b>															
<b>Staffing (estimated)</b>															
Base estimates on past experience.	PP A10.3, PTO A6.3														
Use similar projects when possible.	PP A10.3														
Document staffing estimates in the software development plan.	PTO A6.3														
Use historical data where appropriate.	IM A7.1														
Adapt models used to plan staffing profiles to the project.	IM A7.1														
<b>Staffing distribution (estimated) over the software life cycle</b>	PP A10.3														
<b>Staffing (actual)</b>															
Compare to plan.	PTO A6.3, IM A5.1														
Document all staffing changes that affect commitments.	PTO A6.3 PTO A6.4														

Measures and things to be measured are shown in bold face.

R = Required I = Implied T = Typical E = Example X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2			Level 3			Lv1 4		Level 5	
			P R M	S T P O	S Q M A	O P F	S C D	S C D	Q P M	T P M		
<b>Schedule</b> <b>Schedule (planned)</b> Use a documented procedure to derive each project's schedule. Relate schedule to estimates for sizes of work products or changes. Relate schedule to software effort and costs. Base schedule on experience (use similar projects, if possible). Identify milestones and reviews. Document assumptions. Document and review schedules. Account for critical dependencies - within the software engineering group - between the software engineering group and other groups Account for critical paths.	PP A7.8 PP A12 PP A12.1 PP A12.1 PP A12.2 PP A7.8 PP A12.5 PP A12.6 IM A9.2 IM A9.2 IM A9.2 IM A9.3	R R T T T T R T T T T T										
<b>Completion dates (milestones) (planned)</b> Completion criteria <b>Dates of reviews (planned)</b> Completion criteria <b>Time phasing of activities (planned)</b> <b>Dates of imposed milestones (planned)</b> <b>Critical dependency dates (planned)</b> <b>Other constraints (planned)</b> Activity durations and times between milestones are appropriate to support accuracy in measuring progress. <b>Planned dates for project planning milestones</b>	PP A7.8, PTO A8.1 IM A9.1 PP A7.8 IM A9.1 PP A10.3 PP A12.3 PP A12.3 PP A12.3 PP A12.3 PP A12.4 PP M1	R R I I R T T T T T E										
<b>Schedule for work completed (planned)</b> <b>Completion dates (activities) (planned)</b> <b>Completion dates (other commitments) (planned)</b> <b>Schedule (completion dates) (planned)</b> - activities - milestones - commitments Document these dates in the software development plan. <b>Schedule revisions</b> Document schedule revisions.	PTO A6.1 PTO A8.1 PTO A8.1 PTO A8 PTO A8.1 PTO A8.1 PTO A8.1 PTO A8.1 PTO A8.3	I R R R R R R R R										
<b>Delivery dates (planned) for subcontracted products</b> Dates (planned) for deliveries to the subcontractor Schedule for the project's SQA group's activities SQA milestone dates (planned) SQA work scheduled (planned) SCM milestone dates (planned) SCM work scheduled (planned)	SM M1 SM M1 SQA A2.3 SQA M1 SQA M1 SCM M1 SCM M1	E E R E E E E										

Measures and things to be measured are shown in bold face.

<i>Issue</i>	References	Notes, implied requirements, and points needing clarification	Level 2 P R T S Q C P P T I P M P O M A F D P M E G R M	Lvl 4 Q P Q D C C M M M P M M	Level 5 T P D C C P M M
Action, measure, indicator, or requirement					
Schedule milestones (dates) for process development	OPD M1	The CMM says development, but the context is definition.	P	E	T
Schedule milestones (dates) for process maintenance	OPD M1		R		D
Schedule (dates?) for risk management	IM A10.1		M		C
The schedule for the QPM activities to be performed	QPM A2.4		O		P
Schedule milestones for QPM activities (planned)	QPM M1		F		M
- milestones for establishing process measurements to be used on the project	QPM M1		A		M
- milestones for determining how process data will be collected	QPM M1		M		M
- milestones for collecting the project's process data	QPM M1		A		M
Schedule for software process development	PCM A9.3				
Schedule for software process improvement	PCM A9.3				
Schedule (estimated)	QPM A4.2				
Completion dates (actual) for project planning milestones	PP M1				
Schedule (actual)	PTO A8.1, IM A5.1, PCM A9.3, QPM A4.2		E	X?	E
Completion dates (activities) (actual)	PTO A8.1		R	E	E
Completion dates (milestones) (actual)	PTO A8.1		R		
Completion dates (other commitments) (actual)	PTO A8.1		R		
Schedule (completion dates) (actual)	PTO A8		R		
- activities	PTO A8.1		R		
- milestones	PTO A8.1		R		
- commitments	PTO A8.1		R		
Compare these dates to those documented in the software development plan.	PTO A8.1		R		
Delivery dates (actual) for subcontracted products	SM M1		E		
Dates (actual) for your deliveries to the subcontractor	SM M1		E		
SQA milestone dates (completed)	SOA M1		E		
SQA work completed (actual)	SQA M1		E		
SCM milestone dates (completed)	SCM M1		E		
SCM work completed (actual)	SCM M1		E		
Task completion dates (actual) for software engineering (SE) support to other engineering groups	IG M1			E	
Milestone completion dates (actual) for SE support to other engineering groups	IG M1			E	
Task completion dates (actual) for support by other engineering groups to the software engineering group	IG M1			E	
Milestone completion dates (actual) for support by other engineering groups to the software engineering group	IG M1			E	

**R** = Required      **I** = Implied      **T** = Typical      **E** = Example      **X** = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2			Level 3			Lvl 4			Level 5		
			P	S	O	R	P	T	Q	M	P	T	P	C
Schedule milestones for QPM activities (actual) - dates when process measurements are established for use on the project - dates when the procedures for collecting process data have been determined - dates when the project's process data are collected Compare the actual dates to those in the approved plan.	QPM M1	This statement is unclear. Does the slash imply "and," "or," or a ratio? A better way to say it would be "Plot all three (estimated, planned, and actual) on the same chart."												
	QPM M1													
	QPM M1													
	QPM M1													
Schedule (estimated/planned versus actual)	QPM A4.2													
Schedule time (actual) by project, process stage, program category, program size, degree of program modification, etc. Schedule performance	TCM Ab4													
	PCM A9.3													
Expected cycle-time benefits from process improvement proposals	PCM A5.3													

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2			Level 3			Lvl 4			Level 5			
			P R M	S P P O M	S Q C A M	O P P F D	T I P M E	P P E G R	Q P M M	P P Q M M	T D C P M				
<b>Cost</b> <b>Costs (estimated) for the project</b>  Use a documented procedure. Relate estimates to estimates for size of work products or changes. Include direct labor, overhead, travel, computer costs, etc. Use productivity data (historical or current). Base estimates on past experience. Use similar projects when possible. Use historical data where appropriate. Adapt models used to estimate cost to the project. Adjust the referenced cost data to incorporate project variables. Update the parameter values of the models used in estimating software costs whenever major changes are made to the software requirements. Document and review assumptions. Document and review estimates. Document in the software development plan.	PP A7.6, OPD A5.1, IM A5.3 PP A10 PP A10.1 PP A10.2 PP A10.3 PP A10.4 IM A7.1 IM A7.2 IM A7.4 PP A10.4 PP A10.4 PTO A6.2		R				E	E							
<b>Cost distribution (estimated) over the software life cycle</b> <b>Costs (estimated) for software work products</b> <b>Costs allocated to individually managed tasks or stages</b> <b>Cost (initial estimate) for implementing and testing each incorporated product engineering change</b> <b>Cost data (estimated/planned) used to control the project's defined software process</b>	PP A10.3 OPD A5.1 IM A7.3 PE M2 QPM A4.2	The slash does not appear to mean division. Whether it means "and" or "or" is not clear.	T				E	T	E			E			
<b>Costs (planned) for managing each subcontract</b> <b>Cost over time for QPM activities (planned)</b> <b>Projected cost of planned defect prevention activities</b>	SM M1 QPM M1 DP V1.6			E								E		R	
<b>Costs (actual) for the project</b>  Track, over time, against work completed. Compare to plan. Document all cost changes that affect commitments. <b>Costs (actual) for managing each subcontract</b> <b>Costs (actual) for software work products</b> <b>Costs for process definition activities</b> <b>Cost (actual) for implementing and testing each incorporated product engineering change</b>	PTO A6.1, IM A5.1, A7 PTO A6.1 PTO A6.1, A6.2 PTO A6.4 SM M1 OPD A5.1 OPD M1 PE M2	Work completed must be measured and tracked. Implies periodic measurement & reporting. Implies periodic measurement & reporting.	R				E	R							

Measures and things to be measured are shown in bold face.

Page 16 R = Required I = Implied T = Typical E = Example X = Implied by Example

<i>Issue</i>	References	Notes, implied requirements, and points needing clarification	Level 2	Level 3	Lvl 4	Level 5
Action, measure, indicator, or requirement			P R M P O M A M	O S C P T I P I P E G R M	Q P P P P Q D C C C M M M M	T P C C C M M M
Cost over time for QPM activities (actual) Compare actual costs to those in the plan.	QPM M1				E	
Cost (actual) for achieving software quality goals	QM A4.5					
Cost for achieving quality goals	QM M1					
Cost of poor quality	QM M1	There is a mismatch here. The data needed for computing this are not addressed until Level 5. See the entries for DP A5.2 that follow.			E	
Cost for identifying each defect	DP A5.2	Estimated or actual? The CMM is not explicit here.			R	
Cost for correcting each defect	DP A5.2, M1				E	
Estimated cost of not fixing each defect	DP A5.2				E	
Cost of holding causal analysis meetings	DP M1				E	
Cost of completed defect prevention activities	DP V1.6				E	
Cost of software process development	PCM A9.3				R	
Cost of software process Improvement	PCM A9.3				E	
Costs (estimated) for remaining work Updated estimates use actual productivity data from the current project where appropriate.	IM A7.4 IM A7.4			T T		
Use a documented procedure to manage the project's software costs.	IM A7			R		

[illegible]

**R** = Required    **I** = Implied    **T** = Typical    **E** = Example    **X** = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2			Level 3			Lvl 4			Level 5		
			P	R	T	S	O	O	P	I	P	Q	T	P
			M	P	O	M	A	M	F	D	P	M	E	G
<b>Risk</b> Risks associated with cost, resource, schedule, and technical aspects - priorities - contingencies Risks are tracked. Risks are identified, assessed, documented, and managed according to a documented procedure. Risk priorities (Initial) Risk priorities (revised) Estimated loss for each identified risk Adverse impact (realized) for each identified risk Number of unanticipated adverse impacts Track over time. Magnitude of unanticipated adverse impacts Track over time. Staff resources required for risk management (includes staff & tools)	PTO A10 PTO A10.1 PTO A10.1 PTO A10 IM A10  PTO A10.1 IM A10.6 IM M1 IM M1 IM M1 IM M1 IM M1 IM M1 IM A10.1		R R R R  R						R     T E E E E E E T					
<b>Testing</b> Test efficiency Test coverage Test coverage (to be achieved) Statement coverage Path coverage Branch coverage Usage profile Technical staff receive training in measuring test coverage.	OPD A5.1 OPD A5.1 PE A5.3 PE A5.3 PE A5.3 PE A5.3 PE A5.3 PE Ab2							E E		R E E E E E E				
<b>Scrap and Rework</b> Rework effort resulting from peer reviews	PR A3	Measuring and reducing resources expended for scrap and rework have historically been key elements of process improvement. This is recognized in MIL-STD-498 and in the emerging IEEE-1498 standard. The only place that v1.1 of the CMM addresses this issue is in the Peer Review KPA. It probably should receive more attention. One of the Level-4 KPAs would seem to be an appropriate place.									E			

Measures and things to be measured are shown in bold face.

R = Required I = Implied T = Typical E = Example X = Implied by Example



[illegible]

**R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example**

Issue Action, measure, indicator, or requirement	References	Notes, Implied requirements, and points needing clarification	Level 2			Level 3			Lvl 4			Level 5		
			P	S	S	O	O		Q			T	P	
			R	P	T	R	P	T	R	P	T	R	P	T
			M	P	O	M	P	O	M	P	O	M	P	O
Quality goals for each project's processes Each program's defect history Quality trends for each project	PCM M1 PCM A9.3 PCM M1	Examining quality trends within a project is likely to be difficult and less meaningful than examining them across projects. Perhaps the CMM should focus on project-to-project trends here. Alternatively, it should illustrate ways in which quality trends within projects might be meaningful and useful.												
Software reliability measures	OPD A5.1, QPM A4.2													
Severity of defects in software requirements	OPD A5.1, QPM A4.2 TCM Ab4													
Severity of defects in software code	OPD A5.1, QPM A4.2													
Severity of problem	PE M2, TCM Ab4													
Severity of defects in software products Track cumulatively by stage.	PE M1, TCM Ab4													
Quality goals for each life-cycle stage	QM A3.5, PCM A5.1													
Quantitative goals for each identified quality characteristic	QM A3, A3.3 PCM A5.1 QM A3.3													
Measurable values (required to be achieved) for each identified quality characteristic	QM A3.3													
Measurable values (desired levels) for each identified quality characteristic	QM A3.3													
Quality measures (actual values) for each life-cycle stage	QM A4.2													
Software mean time between failures (MTBF) specified by requirements	QM A3.3													
Software MTBF (planned)	QM A3.3													
Software MTBF that must be achieved, as determined by analysis & experiment	QM A3.3													
Cost (actual) for achieving software quality goals	QM A4.5													

**R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example**

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2			Level 3			Level 4	Level 5	
			P R M	T S O	S Q M	S C A	O C M	P P F	I I D	P P M	Q C M
The organization has a written policy for measuring and quantitatively controlling each project's defined software process.	QM C1										
The organization has a documented procedure for developing and maintaining software quality plans for each project.	QM A1										
The project follows the written organizational policy for managing software quality.	QM C1										
Each project's software management activities support the organization's commitment to improve the quality of software products.	QM C1.1										
Each project defines and collects the measurements used for quality management based on its defined software process.	QM C1.2										
Each project defines quality goals for its software products.	QM C1.3										
Each project monitors its progress towards its quality goals.	QM C1.3										
Each project's responsibilities for software quality management are defined and assigned.	QM C1.4										
Projects establish criteria to enable its groups to determine their success in achieving the quality goals of their software products.	QM C1.4										
Each project has a software quality plan.	QM A1										
Each project's software quality plan is developed and maintained according to a documented procedure.	QM A1										
Each project measures and understands the software quality needs of its organization, customer, and end users. Examples of ways to measure include surveys, focus groups, and product evaluations.	QM A1.1										
Characteristics of product quality (how well it will perform, how well it can be developed and maintained) are identified.	QM A3.1										
Measurements are used to quantify the characteristics of software product quality.	QM A3.2										
Quality goals for software products are documented in each project's software quality plan.	QM A3.4										
Quality goals are defined and documented for each software life-cycle stage.	QM A3.5										
Each project's quantitative quality goals are monitored and revised throughout the software life cycle.	QM A3										
Quality goals for the product and its life-cycle stages are revised as understanding of the product and of the organization's, customers', and end user's needs evolve.	QM A3.6										
Predicted values for the number of post-delivery defects are tracked and updated as the product matures.	QM A1.2										
Product quality is measured, analyzed, and compared to goals.	QM A4 & A4.3										

The CMM appendixes "...on an event-driven basis." This appears to have no semantic content.

Page 21

**R** = Required    **I** = Implied    **T** = Typical    **E** = Example    **X** = Implied by Example

# **CMM v1.1 Measurement Map**

## **Part 2**

### **Key Process Areas and Activities**

<b>Topic</b>	<b>Page</b>
Requirements Management	23
Planning	24
Tracking	26
Subcontract Management	27
Software Quality Assurance	28
Software Configuration Management	28
Process Development and Improvement	29
Process Definition (organizational focus)	29
Process Definition (project focus)	29
Training	30
Integrated Software Management	30
Software Product Engineering	30
Intergroup Coordination	31
Peer Reviews	32
Process Management (project focus)	33
Process Management (organizational focus)	40
Process Management (enterprise focus)	42
Tools	42
Defect Prevention	43
Technology Change Management	45
Process Change Management	46

[illegible]

**R** = Required    **I** = Implied    **T** = Typical    **E** = Example    **X** = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2					Level 3					Level 4					Level 5				
			P	S	S	O	O	P	S	O	O	P	Q	P	Q	P	Q	T	P	D	C	C
<b>Planning</b> Measurements are made and used to determine the status of software planning activities. <b>Planned dates for project planning milestones</b> <b>Completion dates for project planning milestones</b> <b>Work completed (for planning tasks)</b> <b>Effort expended (for planning tasks)</b> <b>Funds expended (for planning tasks)</b>	PP M1 PP M1 PP M1 PP M1 PP M1	Implies the need for completion criteria. These should be stated explicitly.	R																			
Planning data are recorded. These include - estimates - Information needed to reconstruct estimates Planning data are archived.	PP A15 PP A15.1 PP A15.1 PTO A11.3	Recorded where? Since this is part of a Level-2 KPA, this appears to ask only that the data and estimates be recorded at the project level, in some project artifact. Archived where? In what form? How does archived differ from recorded? What ensures that data 'archived' at Level 2 are available for (and get inserted into) the software process database at Level 3? "Recorded" and "archived" are not defined in the CMM's glossary. Perhaps they should be, so that notes stuffed in a desk drawer or stored in a box in the basement are not viewed as satisfying this requirement. Are storage and archiving the same things?	R																			
Each project provides appropriate software planning data for storage.	IM A5.3																					
<b>Size of code (estimated)</b> - generated - fully tested - delivered <b>Effort (estimated)</b> Document these estimates in the software development plan. <b>Staffing (estimated)</b> Document these estimates in the software development plan. <b>Costs (estimated)</b> Document these estimates in the software development plan. <b>Units of delivered documentation (estimated)</b> Document this estimate in the software development plan. <b>Work completed (estimated) versus time and/or estimated effort and costs</b> <b>Critical computer resources for each major component</b> Document these estimates in the software development plan. <b>Schedule (completion dates) (planned)</b> - activities - milestones - commitments Document these dates in the software development plan. <b>Release contents for successive builds (planned)</b>	PTO A5.2 PTO A5.2 PTO A5.2 PTO A5.2 PTO A6 PTO A6.1, 6.3 PTO A6.3 PTO A6.3 PTO A6 PTO A6.1, 6.2 PTO A5.3 PTO A5.3 PTO A6.1 PTO A7 PTO A7.1 PTO A8 PTO A8.1 PTO A8.1 PTO A8.1 PTO A8.1 PTO A8.1 PTO A9.2		R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R

Measures and things to be measured are shown in bold face.

R = Required I = Implied T = Typical E = Example X = Implied by Example

# CMM v1.1 Measurement Map

Issue	Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level											
				Level 2			Level 3			Level 4			Level 5		
				P	R	T	P	O	O	P	P	P	P	T	P
				M	P	M	M	A	F	D	P	E	G	R	M
Replanning data are recorded. These include - estimates - information needed to reconstruct and verify estimates Replanning data are archived. Each project provides appropriate software replanning data for storage.		PTO A11.1 PTO A11.1 PTO A11.3 IM A5.3	Where? How does archived differ from stored? "Appropriate" begs definition. What are the criteria for appropriate? Who determines them? If it's all arbitrary, then any data suffices.	R											
Each project has a measurement plan. Project measurement plans are included in the organization's library of process-related documentation.		OPD A6 OPD A6							E	E					
Frequency of replanning Magnitude of replanning effort Causes of replanning effort		IM M1 IM M1 IM M1									E	E	E		

Measures and things to be measured are shown in bold face.

R = Required I = Implied T = Typical E = Example X = Implied by Example

# CMM v1.1 Measurement Map

Issue	References	Notes, implied requirements, and points needing clarification	Level 2					Level 3					Level 4					Level 5				
			P	S	S	O	O	R	P	T	I	P	P	Q	P	Q	P	T	P	P	M	M
<b>Action, measure, indicator, or requirement</b>			R	P	T	S	Q	C	C	P	P	T	I	P	I	P	P	Q	D	C	C	
<b>Tracking</b>			R	M	P	O	M	A	M	F	D	P	M	E	G	R	M	M	P	M	M	
<b>Size of (major) software work products</b>	PTO A5, A5.1	Tracking implies periodic measurement & reporting. "Major" is not defined.	R																			
<b>Size of changes to software work products</b>	PTO A5		R																			
<b>Size of code</b>	PTO A5		R																			
<b>- generated</b>	PTO A5.2		R																			
<b>- fully tested</b>	PTO A5.2		R																			
<b>- delivered</b>	PTO A5.2		R																			
<b>Compare these sizes to estimates documented in the software development plan.</b>	PTO A5.2		R																			
<b>Units of delivered documentation</b>	PTO A5.3		R																			
<b>Compare this measure to estimates documented in the software development plan.</b>	PTO A5.3		R																			
<b>Projected size of software work products (estimates plus actuals)</b>	PTO A5.4		R																			
<b>Refine, monitor, and adjust on a regular basis.</b>	PTO A5.4	R																				
<b>Effort</b>	PTO A6	R																				
<b>Track over time.</b>	PTO A6	R																				
<b>Compare against work completed.</b>	PTO A6.1	R																				
<b>Compare against estimates documented in the software development plan.</b>	PTO A6.1	R																				
<b>Staffing</b>	PTO A6.1, 6.3	R																				
<b>Track over time.</b>	PTO A6.3	R																				
<b>Compare against estimates documented in the software development plan.</b>	PTO A6.3	R																				
<b>Costs</b>	PTO A6	R																				
<b>Track over time.</b>	PTO A6.1	R																				
<b>Compare against work completed.</b>	PTO A6.1	R																				
<b>Compare against estimates documented in the software development plan.</b>	PTO A6.1	R																				
<b>Work completed</b>	PTO A6.1	R																				
<b>Track over time.</b>	PTO A6.1	R																				
<b>Compare to work planned.</b>	PTO A6.1	R																				
<b>Critical computer resources (actual use)</b>	PTO A6.1	R																				
<b>Compare to estimates for each major component documented in the software development plan.</b>	PTO A7.1	R																				
<b>Critical computer resources (projected use)</b>	PTO A7.1	R																				
<b>Compare to estimates for each major component documented in the software development plan.</b>	PTO A7.1	R																				
<b>Schedule (completion dates) (actual)</b>	PTO A7.1	R																				
<b>- activities</b>	PTO A8	R																				
<b>- milestones</b>	PTO A8.1	R																				
<b>- commitments</b>	PTO A8.1	R																				
<b>Compare these dates to those documented in the software development plan.</b>	PTO A8.1	R																				
<b>Software engineering technical activities</b>	PTO A8.1	R																				
<b>- technical status</b>	PTO A9	R																				
<b>People report their status to first line managers on a regular basis.</b>	PTO A9.1	R																				
<b>Release contents for successive builds (actual)</b>	PTO A9.1	R																				
<b>Compare these to the plans documented in the software development plan.</b>	PTO A9.2	R																				
<b>Problem reports</b>	PTO A9.2	R																				
<b>Track to closure</b>	PTO A9.4	R																				
<b>Risks associated with cost, resource, schedule, and technical aspects</b>	PTO A9.4	R																				
<b>- priorities</b>	PTO A10	R																				
<b>- contingencies</b>	PTO A10.1	R																				
	PTO A10.1	R																				

Measures and things to be measured are shown in bold face.

R = Required I = Implied T = Typical E = Example X = Implied by Example



# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level										Lvl 4	Level 5
			P	S	O	P	T	I	P	I	P	P	Q	T
Risk			R	P	S	O	P	T	I	P	I	P	Q	T
			M	P	O	M	F	D	P	M	E	G	R	M
- number of unanticipated adverse impacts - magnitude of unanticipated adverse impacts	IM M1 IM M1													
Actual measurement data are recorded. Actual measurement data are archived.	PTO A11 PTO A11.3	Recorded where? This should be spelled out. How does archived differ from recorded?	R											
Measurements are made and used to determine the status of software tracking and oversight activities	PTO M1		R											
Effort expended in performing tracking and oversight	PTO M1 PTO M1		E											
Other resources expended in performing tracking and oversight	PTO M1 PTO M1		E											
Change activity for the software development plan: Size estimate change activity Cost estimate change activity Critical computer resource estimate change activity Schedule change activity	PTO M1, TCM Ab4 PTO M1, TCM Ab4 PTO M1, TCM Ab4 PTO M1, TCM Ab4 PTO M1, TCM Ab4		E											X
Number of defects in software products Track cumulatively by life-cycle stage. Types of defects in software products Track cumulatively by stage. Severity of defects in software products Track cumulatively by stage.	PE M1 PE M1 PE M1, TCM Ab4 PE M1, TCM Ab4 PE M1, TCM Ab4 PE M1, TCM Ab4		E											X
Number of changes incorporated into the software baseline by category - number of interface changes - number of security changes - number of system configuration changes - number of performance changes - number of usability changes Number of action items Rate of closure of action items	PE M2 PE M2 PE M2 PE M2 PE M2 PE M2 QPM A4.2 QPM A4.2		E											X
Change activity for software products and work processes: Amount of code produced Amount of documentation produced	TCM Ab4 TCM Ab4 TCM Ab4													E
														E
														E
<b>Subcontract Management</b> Measurements are made and used to determine the status of activities for managing the software subcontract.	SM M1	Implies separate measurements for each subcontractor.	R											

Measures and things to be measured are shown in bold face.

R = Required I = Implied T = Typical E = Example X = Implied by Example

[illegible]

<b>Software Configuration Management</b>	Measurements are made and used to determine the status of the SCM activities. Number of change requests per unit time The date each change request is processed SCM milestone dates (planned) SCM milestone dates (completed) SCM work scheduled (planned) SCM work completed (actual) SCM effort expended (planned) SCM effort expended (actual) SCM funds expended (planned) SCM funds expended (actual)	Processing completion dates must be recorded. Completion criteria must be defined.	R E X  E E E E E E E E E E
--	--	---	---

**R** = Required      **I** = Implied      **T** = Typical      **E** = Example      **X** = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2			Level 3			Lvl 4			Level 5		
			P R M	S T O	S Q A	S C M	O P E	O P E	Q P R	Q P R	T P C	T P C	P M M	P M M
<b>Process Development and Improvement</b> Measurements are made and used to determine the status of the organization's process development and improvement activities. <b>Work (planned) for process assessment</b> <b>Work (completed) for process assessment</b> <b>Effort (planned) for process assessment</b> <b>Effort (expended) for process assessment</b> <b>Funds (planned) for process assessment</b> <b>Funds (expended) for process assessment</b> Results of process assessments Recommendations from previous assessments <b>Work (planned) for process development and improvement</b> <b>Work (completed) for process development and improvement</b> <b>Effort (planned) for process development and improvement</b> <b>Effort (expended) for process development and improvement</b> <b>Funds (planned) for process development and improvement</b> <b>Funds (expended) for process development and improvement</b>	OPF M1  OPF M1 OPF M1 OPF M1 OPF M1 OPF M1 OPF M1 OPF M1 OPF M1 OPF M1 OPF M1 OPF M1 OPF M1 OPF M1 OPF M1	  <												

Measures and things to be measured are shown in bold face.

R = Required I = Implied T = Typical E = Example X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level										Lvl 4	Level 5
			P	R	T	S	S	O	O	P	I	P	Q	T
			M	P	O	M	A	M	F	D	P	E	G	R
<b>Training</b> Measurements are made and used to determine the status of the training program activities. <b>Attendance (projected) at each course</b> <b>Attendance (actual) at each course</b> <b>Number of training waivers approved (over time)</b> Progress in providing training courses compared to project's plan Progress in providing training courses compared to organization's plan	TP M1 TP M1 TP M1 TP M1 TP M1 TP M1	*Projected* seems to mean something different here than when used to describe size measures.												
Quality of the training program Course reviews from students Results of post-training tests Feedback from software managers	TP M2 TP M2 TP M2 TP M2													
The individuals who develop a project's defined software process receive training in using the software process database. Software managers receive training in software estimating. Software managers receive training in software tracking. Technical staff receive training in measuring test coverage. Individuals implementing or supporting quantitative process management receive the training needed to perform these activities. Examples of training include - modeling and analyzing the software process - selecting, collecting, and validating process measurement data - applying basic quantitative methods and analysis techniques, such as estimation models, Pareto diagrams, and control charts All members of the software engineering group and related groups receive orientation on the value and goals of quantitative process management. Individuals implementing and supporting software quality management receive training in measuring product and process quality.	IM Ab2 IM Ab3 IM Ab3 PE Ab2 QPM Ab4 QPM Ab4 QPM Ab4 QPM Ab4 QPM Ab4 QM Ab2	Since a distinction was made earlier between supporters and performers, this statement (taken literally) seems to imply that performers do not need training. This was not the intent of the authors of the CMM.  *Orientation* is not defined.												
<b>Integrated Software Management</b> Measurements are made and used to determine the effectiveness of the integrated software management activities.	IM M1													
<b>Software Product Engineering</b> Measurements are made and used to determine the functionality of the software products. Measurements are made and used to determine the status of software product engineering activities.	PE M1 PE M2	Examples of functionality measures are listed in the "Requirements" section of this mapping. The examples the CMM gives for status measures are listed with their related items in preceding sections.												

Measures and things to be measured are shown in bold face.

R = Required I = Implied T = Typical E = Example X = Implied by Example

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2		Level 3		Lvl 4		Level 5	
			P	S	S	O	O	Q	P	Q
<b>Inter-group Coordination</b> Measurements are made and used to determine the status of the intergroup coordination activities. Effort (actual) expended by the SE (software engineering) group to support other engineering groups Other resources expended by the SE group to support other engineering groups Effort (actual) expended by other engineering groups to support the software engineering group Other resources expended by other engineering groups to support the software engineering group Task completion dates (actual) for SE support to other engineering groups Milestone completion dates (actual) for SE support to other engineering groups Task completion dates (actual) for support by other engineering groups to the software engineering group Milestone completion dates (actual) for support by other engineering groups to the software engineering group	IG M1 IG M1 IG M1 IG M1 IG M1 IG M1 IG M1 IG M1 IG M1 IG M1		R E E E E E E E E E	P P P P P P P P P P	I I I I I I I I I I	P P P P P P P P P P	Q Q Q Q Q Q Q Q Q Q	P P P P P P P P P P	T T T T T T T T T T	P P P P P P P P P P

**R** = Required    **I** = Implied    **T** = Typical    **E** = Example    **X** = Implied by Example

## CMM v1.1 Measurement Map

[illegible]

Measures and things to be measured are shown in bold face.

Page 32

**R** = Required    **I** = Implied    **T** = Typical    **E** = Example    **X** = Implied by Example

[illegible]

**R** = Required    **I** = Implied    **T** = Typical    **E** = Example    **X** = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2					Level 3					Level 4		Level 5																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
			P	R	T	S	Q	M	A	F	O	O	P	P	T	S	Q	P	T																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
			M	P	O	M	A	M	F	O	O	P	P	T	I	P	I	P	Q	D																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						

Measures and things to be measured are shown in bold face.



# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level									
			P	R	P	T	S	S	O	O	Q	T
			M	P	O	M	A	M	F	D	P	M
Each project documents precise definitions for the measurement data to be collected to control its defined software process. Each project defines and documents the intended use and analysis of each measurement used to control its defined software process.	QPM A4.2 QPM A4.2	This requirement seems to preempt QPM A5.8.										
Each project predefines the data analysis activities it will use to control its defined software process.	QPM A5.1											
Each project's predefined description of data analysis activities covers - input data required - tools used - data manipulations performed - information to be derived - decision criteria to be used in (a) performing each analysis and (b) deciding what actions to take Each project's predefined data analysis techniques include - Pareto diagrams - control charts	QPM A5.1 QPM A5.1 QPM A5.1 QPM A5.1 QPM A5.1  QPM A5.1 QPM A5.1											
- trend diagrams - scatter diagrams Each project defines and documents the process control points at which its process control data will be collected.	QPM A5.1 QPM A5.1 QPM A4.2	It would be helpful if the CMM could provide examples of where and how control charts might be useful to software projects. Without examples of control charts that work for software, this statement leaves users of the CMM grasping at straws. Alternatively, a pointer to [Wheeler 92] would be helpful.										
Each project's process control measurements are chosen from the entire life cycle (including post-development stages). The measurements used to control the project's defined software process appropriately characterize the process. The measurements cover the properties of the key software process activities. The measurements cover the properties of the major software work products. The measurements to be controlled are a natural result of the software activities where possible. The measurements are selected to support predefined analysis activities. Measurements that are research oriented should be explicitly identified as such. The validity of the measurement data is independently assessed.	QPM A4.3  QPM A5.3  QPM A4.4 QPM A4.4 QPM A4.6  QPM A4.7 QPM A4.7 QPM A4.8	The CMM appends "they represent." This seems redundant.  "Major" is not defined. The CMM is not clear here. What are "controlled measurements"? What is a "natural result"?  Validity of a measure is a different issue from that of correctness of the data. The CMM needs to be clearer here as to which it is asking for. Perhaps it should ask for both. Perhaps the CMM should point out that validity of data (or measurement definitions) can only be judged in the context of intended use. Furthermore, if predictive validity is desired, this can only be verified with empirical evidence that the predictions work. Also, "independently assessed" should be defined.										

Measures and things to be measured are shown in bold face.

R = Required I = Implied T = Typical E = Example X = Implied by Example

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2			Level 3			Lvl 4	Level 5
			P R M	S T O	S C Q	O P F	O D M	P I P E G		
Each project establishes a process performance baseline.	QPM A5.5	Process performance baseline is defined in the CMM's glossary.								
When new software projects are substantially different from past projects, new process performance baselines are established for those projects as part of tailoring the organization's standard software process. Examples of substantial differences include - new application domains - use of radically different technologies - significant change in the size of the application	QPM A7.6  QPM A7.6 QPM A7.6	Should perhaps a distinction be made between a baseline based on needs (requirements) and a baseline based on extrapolations from demonstrated process performance. There is great danger when the two are confused. "Radical" may be too strong a word here. "Change" is not a good word here. The issue is whether the new project differs significantly in size from projects for which the organization's standard software process was designed. This is different from change in size since the start of the project. Excellent! But to avoid confusing the innocent, it should be pointed out that process capability cannot be established until the process is brought under statistical control (i.e., is operating stably).								
Changes to the organization's standard software process are tracked and analyzed to assess their effects on the process capability baseline.	QPM A7.7									
Specify the expected values for the mean and variance of each measurement.	QPM A5.4	This is statistically erroneous. Expected values are never "specified." The data determine SAMPLE means and variances, which are often used to estimate the true means and variances. Perhaps the CMM means to say "target values." But SW process measures will seldom have stationary process means. Instead, we will usually be dealing with trajectories, such as cumulative effort, cost, work completed, problems reported, or problems fixed. Mean and expected value are concepts that seem more applicable to end-of-project data. But then they are not very useful for control purposes in the classical sense. Perhaps a better analogy when trajectories are being tracked is that of navigation (flight planning) and course correction.								
Each project defines acceptable limits for the measurements it uses to control its defined software process.	QPM A5.5	Be very careful here. Limits defined arbitrarily lead to overcontrolling and to destabilized processes. It would be wise to distinguish between the "voice of the customer" and the "voice of the process" if intelligent and effective actions are to be taken on the basis of these limits. See [Wheeler 92] and [Wheeler 95].								

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level					Level				
			P	R	M	P	T	S	O	O	Q	T
An example of establishing acceptable limits is to calculate the historical deviation from the mean performance of the process.	QPM A5.5	This is confused and confusing. The preceding statement implies that limits for controlling project parameters such as size, effort, schedule, cost, and defects are what are wanted. These usually involve profiles over time (i.e., trajectories). What is needed are prediction intervals for these profiles, set according to some criteria that permits rare events to be identified. The profiles can be estimated only with a model that accounts for differences among projects. Except in the simplest of situations, calculating "the historical deviation from the mean performance of the process" will be both impossible and useless. Also, this kind of wide ranging variation is NOT what one should use to construct control limits [Wheeler 92].										
Each project compares the actual values of its measurements to the expected values of the means and variances.	QPM A5.6	Projects will never know what the "expected" values are (in the probabilistic sense). The best they will ever have is the organization's estimates for these values. But even this presumes either that the project follows exactly the same process and that the product has exactly the same characteristics (size, reuse, language, application, etc.) as all others in the set used to develop the estimates, or that competent cost models are competently used to account for these differences. Today's cost models ATTEMPT (but don't necessarily succeed) to estimate expected "means," but few (if any) address variances in any realistic way. It would be more reasonable to require use of a model that estimates expected values and variances based on extrapolations from past projects. What is really needed is not estimates at completion, but estimates of the trajectories one expects to see over time. Perhaps the real issues the CMM should address here are (a) comparison of actual values to planned values, and (b) comparison of the plan to historical experience.										
Projects adjust their processes to bring performance in line with the defined acceptable limits.	QPM A5.7	Limits that are too narrow cause overcontrolling, instability, and degradations in performance. The advice the CMM gives here should be accompanied by guidance that makes this clear. Also, adjustment alone is unlikely to help. It is almost always more effective to focus on identifying assignable causes and removing them, then work on process improvement.										

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2			Level 3			Level 4			Level 5		
			P M P O	T S Q C	S S Q C	O O P P	T T I P	I I P P	Q Q P P	M M P P	M M P P	T T P P	T T P P	T T P P
When the project's defined software process is controlled quantitatively, baselines are established for	QPM A5.8	From the context, the intent appears to be, "To control its defined SW process quantitatively, each project should establish (statistically derived?) baselines for..." Since "definition" is singular here, this appears to say that each process is to establish a baseline for its definition process. The context, though, suggests that each project is to establish baseline definitions for the measures it uses to control its SW process. But that requirement is already stated in QPM A4.2. Is QPM A5.8 redundant here?												
- the definition of measurements	QPM A5.8													
- the actual measurement data	QPM A5.8	The intent here is not clear. In what sense are baselines established for actual measurement data?												
- the acceptable limits for the measurements	QPM A5.8	How does establishing baselines for acceptable limits differ from simply establishing acceptable limits? Perhaps the CMM should point out that there are statistically valid ways for doing this (i.e., Shewhart's control charts). This may be important, since in practice invalid limits seem rampant.												
Manage and control the process performance baseline for each software project.	QPM A5.9													
The data collected to control each project's defined software process is stored in the organization's software process database, if appropriate.	QPM A4.9													
Each project's defined software process is analyzed and brought under control according to a documented procedure.	QPM A5													
Identify, collect, and analyze measurement data on process activities throughout the project's defined software process.	QPM A5.2	Are there any activities that are not "process" activities?												
Prepare and distribute reports that document the results of each software project's activities.	QPM A6	This is not always the smart thing to do. In some instances it is best to leave control charts in the hands of the people who operate and manage the process. Otherwise they become a "big brother is watching you" club that is used to beat people around the shoulders.												
The results of data analysis (of the project's QPM activities) are reviewed with those affected by the data before they are reported to anyone else.	QPM A6.1													
Software managers, task leaders, and senior managers receive regular reports (of the project's QPM activities) appropriate to their needs.	QPM A6.2	For this to be a testable requirement, each organization or project should establish definitions for "appropriate" and "regular."												
The project manager, senior managers, software managers, and software task leaders receive specialized reports (of the project's QPM activities) on request.	QPM A6.4													
The software quality assurance group receives regular reports (of the project's QPM activities) appropriate to its needs.	QPM A6.3	For this to be a testable requirement, each organization or project should establish definitions for "appropriate" and "regular."												

Measures and things to be measured are shown in bold face.

## CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2					Level 3					Lv1 4		Level 5																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
			P	S	S	O	S	R	P	T	S	Q	C	P	P	T	P																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
			M	P	O	M	A	M	F	D	P	M	E	G	R	I	P	Q	D	C	C	P	P	M	M	M	M																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
Measurements are made and used to determine the status of the activities for quantitative process management.	QPM M1	The context makes it appear that this applies to the project's QPM activities rather than to those of the organization. Should there not also be an organizational focus?																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													</

Measures and things to be measured are shown in bold face.

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level										Lvl 4	Level 5
			P	R	M	P	O	A	S	S	O	P	Q	T
<b>Process Management (organizational focus)</b> An organization-wide measurement program exists.	QPM Ab2.2	It's not at all clear that an organization-wide "program" is a prerequisite for successful process management. What's needed is organization-wide use of measurement practices that guide and motivate process management toward productive directions and that enable decisions to be based on factual information. A "program" is only one way to get there, and maybe not the best way at that. Perhaps organization-wide measurement "practices" would be better? It's not clear what "organization-wide measurements" might be. Perhaps "measures that address organization-wide issues" would be more accurate.											R	
The organization-wide measurement program includes - definition of organization-wide measurements - collection of organization-wide measurements - analysis of organization-wide measurements - quantitative measurement goals for the organization	QPM Ab2.2 QPM Ab2.2 QPM Ab2.2 QPM Ab2.2												E	E
A written policy for analyzing the process capability of the organization's standard software process exists.	QPM C2												E	E
A process capability baseline for the organization's standard software process is established and maintained.	QPM A7	This may not be easy. Establishing a process's capability requires that the process be brought under statistical control (shown to be stable). What variables does the CMM perceive should be measured to demonstrate its concept of stability? Without some elaboration here, this may be an impossible requirement. Excellent! But is this intended to apply to software subprocesses, or just to the overall software process? The meaning of "documented" is unclear here. For example, what constitutes acceptable documentation? The customary way to document process capability is to use control charts and performance histograms, sometimes supplemented by capability ratios. If this is what the CMM means, it should say so. If not, it should make its intent clear.											R	
Measurements of process performance are analyzed to establish and maintain a process capability baseline.	QPM C2.1												T	
The process capability baseline for the organization's standard software process is documented.	QPM A7.3												T	
A documented procedure is used to establish and maintain the process capability baseline.	QPM A7												R	
The process capability baseline for the organization's standard software process is managed and controlled.	QPM A7.5												T	
The process capability baseline includes standard definitions and expected ranges for the measurements used.	QPM C2.1	This may be neither realistic nor practical. Perhaps the CMM should instead require standardized reporting and recording of definitions used for measurements. Note that "expected ranges" presuppose data about the future that are not yet in evidence. Assurances that a process will continue to operate in the same fashion and in the same environment in the future as in the past are the responsibility of the project or process manager, not of any statistical methods that might be used for baselining. The distinctions between analytic and enumerative studies are important here.											E	

Measures and things to be measured are shown in bold face.

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2			Level 3			Lvl 4	Level 5
			P R M	T S O	S Q C	O P F	O P D	Q P M	T P Q	
The process performance baseline for each project's defined software process is incorporated (as appropriate) into the process capability baseline for the organization's standard software process.	QPM A7.2	The purpose is to update the organization's baseline. Actual performance data should be used, not the project's "process performance baseline" established at the start of the project. The CMM uses the term "process performance baseline" in both an anterior and a posterior sense. This introduces confusion. (Compare QPM A5.5, 5.8, and 7.2) This may be an impossible requirement. When a project's actual software process differs from the organization's standard process (and it invariably will), there may be no completely valid way to aggregate the measured values with those of other projects. At best, it will require the use of models to normalize the data.								
Process capability trends for the organization's standard software process are examined to predict likely problems or (and?) opportunities for improvements. Examples of using capability trends include	QPM A7.4	"And" seems to convey the intent better (i.e., why not do both?) The examples that follow are misplaced. They have nothing to do with QPM A7—establishing and maintaining a baseline according to a documented procedure. Is this example misplaced? It seems to deal with project issues, not organizational issues. This example is misplaced. It deals with project issues, not organizational issues.							T	
- predicting software defects and comparing predictions to actuals	QPM A7.4									E
- predicting the distribution and characteristics of defects remaining based on data from peer reviews and/or testing	QPM A7.4									E
A group exists to coordinate the quantitative process management activities for the organization. This group is either part of the group responsible for the organization's software process activities (e.g., the software engineering process group), or its activities are closely coordinated with that group. Adequate resources and funding are provided for quantitative process management activities. Support exists for collecting, recording, and analyzing data for selected process and product measurements. ("Product" data refers to product measurements used for analyzing the software process.) Individuals implementing or supporting quantitative process management receive the training needed to perform these activities. Examples of training include	QPM Ab1 QPM Ab1.1 QPM Ab2 QPM Ab3 QPM Ab4	Does "group" imply at least two individuals? If so, why not say so? Alternatively, if one person might suffice in a small organization, say so. "Adequate" is undefined. Without criteria for "adequate," this requirement has no semantic content. "Support" is not defined—little semantic content here.							R	
- modeling and analyzing the software process										R
- selecting, collecting, and validating process measurement data										R
- applying basic quantitative methods and analysis techniques, such as estimation models, Pareto diagrams, and control charts										R
All members of the software engineering group and related groups receive orientation on the value and goals of quantitative process management.										R
The activities for quantitative process mgt are reviewed periodically with senior mgt.	QPM V1									R

Measures and things to be measured are shown in bold face.

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2			Level 3			Level 4			Level 5		
			P	R	M	P	T	S	O	O	P	P	T	P
<b>Process Management (enterprise focus)</b>		The CMM does not address the use of software measurements for enterprise management. For example: How much software do we have? How much in each language? How many programmers? Designers? Systems engineers? What is our inventory of software tools? What is our annual investment in CASE and other software tools? What are our trends related to these measures? Etc. Mature organizations address these questions—but at what level? And which KPAs should they be tied to?												

<b>Tools</b>														
Tools to support software project planning activities are provided.	PP Ab3.2 PP Ab3.2		R	E										
- estimating models														
Tools to support quantitative process management are made available.	QPM Ab2.3 QPM Ab2.3 QPM Ab2.3 QPM Ab2.3 QPM Ab2.3													
- source code analyzers														
- test coverage analyzers														
- database systems														
- quantitative analysis packages														
- problem-tracking packages														
Support exists for collecting, recording, and analyzing data for selected process and product measurements. ("Product" data refers to product measurements used for analyzing the software process.)	QPM Ab3	"Support" is not defined—little semantic content here.												
Tools to support predicting, measuring, tracking, and analyzing software quality are made available.	QM Ab1.2 QM Ab1.2 QM Ab1.2 QM Ab1.2 QM Ab1.2 QM Ab1.2													
- data collection tools														
- database systems														
- spreadsheet programs														
- software life-cycle simulators														
- quantitative analysis tools														
- code audit tools														
The organization's software process improvement plan covers the tools needed to implement the plan.	PCM A4.1													R

Measures and things to be measured are shown in bold face.



[illegible]

**R** = Required      **I** = Implied      **T** = Typical      **E** = Example      **X** = Implied by Example

## CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2			Level 3			Lvl 4		Level 5						
			P	S	S	O	O	P	T	I	P	O	L	T			
			R	M	P	O	M	A	F	D	P	E	G	R	M	M	P
Number of action items proposed Number of action items open Number of action items closed Profiles of the numbers of action items proposed, open, and closed Number of defects Number of defects Injected in each stage (cumulatively for each project) Number of defects Injected in each stage over releases of similar products	DP V1.4 DP V1.4 DP V1.4 DP M1  DP M1 DP M1	It is unlikely that raw totals are useful for comparing across projects. They certainly need to be collected, but normalizing for factors like size and reuse is needed to make comparisons valid.															R R R E  E E
Summary of major defect categories Frequency distribution of defects in major defect categories Summary of action categories, for actions related to defects Frequency distribution of major action categories related to defects Summary status of action proposals Summary status of action items A summary of the effectiveness and savings attributable to defect prevention activities Cost of holding causal analysis meetings Cost of completed defect prevention activities Projected cost of planned defect prevention activities	DP A8, V1.1 DP A8, V1.1 DP V1.2 DP A8 DP A8 DP V1.5  DP M1 DP V1.6 DP V1.6																R R R R R R R R E R R R
Defect prevention data are tracked across the teams coordinating defect prevention activities. Members of the software engineering group and other software-related groups receive feedback on the status and results of the organization's and project's defect prevention activities on a periodic basis. Compare time and cost for identifying and correcting defects with estimated cost of not correcting the defects.	DP A5  DP A8  DP M1		It's not clear how one compares time to estimated cost. Perhaps estimated times should be recorded as well.														

Measures and things to be measured are shown in bold face.

**R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example**

<i>Issue</i>	References	Notes, implied requirements, and points needing clarification	Level 2	Level 3	Lvl 4	Lvl 5
Action, measure, indicator, or requirement			P R M	S T O	O P I P E G R	T P Q D C C M M
<p><b>Technology Change Management</b></p> <p>Experienced staff members with expertise in software measurement are available to help evaluate, plan, and support initiatives for technology change management.</p> <p>Support exists for collecting and analyzing data needed to evaluate technology changes:</p> <ul style="list-style-type: none"> <li>- Support for recording selected product and process data automatically</li> <li>- Support for data analysis</li> <li>- Support for displaying selected data</li> <li>- Results of data analysis are presented in formats that appropriately convey the information content, e.g., graphical displays</li> </ul> <p><b>Data on software processes and work products that support selecting and evaluating technology changes</b></p> <p>The group responsible for technology change management receive training in</p> <ul style="list-style-type: none"> <li>- the analytical and support facilities available to the organization</li> <li>- principles of statistical quality control</li> </ul>	TCM Ab2.1  TCM Ab3  TCM Ab3.1 TCM Ab3.2 TCM Ab3.3  TCM Ab4  TCM Ab5 TCM Ab5					E   R  R R R E  R    E E  R
<p>Measurements are made and used to determine the status of the organization's activities for technology change management.</p> <p><b>Number of technology changes</b></p> <p><b>Types of technology changes</b></p> <p><b>Sizes of technology changes</b></p> <p><b>Goals of technology changes</b></p> <p><b>Effects of technology changes, compared to the goals</b></p>	TCM M1  TCM M1 TCM M1 TCM M1 TCM M1 TCM M1					R  E E E E E E

**R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example**

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 3					Level 4				
			P	R	M	P	O	S	S	O	O	T
<b>Process Change Management</b> The organization has quantitative, measurable goals for software process improvement. Tools are made available to support statistical analysis of process improvement. Changes to the organization's standard software process are tracked. The strategy for collecting data to measure and track the change in process performance when transferring a software process improvement into normal practice is documented, reviewed, and agreed to by individuals responsible for implementing the processes affected by the change. Support tools are instrumented, as appropriate, to record the desired performance data automatically. The organization's software process improvement plan covers the resources needed to implement the plan. <b>Staff</b> <b>Tools</b>	PCM C1.1 PCM C1.1 PCM C1.3 PCM A2.7 PCM A8.2  PCM A8.2 PCM A4.1 PCM A4.1 PCM A4.1	Presumably, "instrumented" means "used." The CMM could be clearer here.										T T E R T
Each proposal Expected benefits of each software process improvement proposal Priority of software process improvement proposals selected for implementation Initiation (date?)	PCM A5.3 PCM A5.4 PCM A9.1											T T I
Status of each software process improvement proposal Defined goals for implementing each process improvement The actual effect of implementing each process improvement Response time for each software process improvement proposal	PCM A5.7 PCM A9.1 PCM M1 PCM M1 PCM A5.8	The wording in the CMM leaves a bit to be desired. It seems to be asking for a date, but whether this is the initiation date for the proposal or for the implementation is not clear. It would make sense to record both.  The CMM is not clear whether this is the response time for the action or for the benefit.										T R E E I
Aggregate process improvement activities Measurable short-term goals for process improvement Measurable long-term goals for process improvement Measured effectiveness of activities within the software process Accomplishments of process improvement activities Participation in process improvement activities Customer satisfaction indicators Status of process improvement activities Number of proposals submitted Number of proposals open Number of proposals completed	PCM A4.3 PCM A4.3 PCM A5.1 PCM A2.6 PCM A2.6 PCM A3.1 PCM A2.6, A10.3 PCM A10.3 PCM A10.3 PCM A10.3											R R E E R R T R R R R

Measures and things to be measured are shown in bold face.

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2		Level 3		Level 4	Level 5
			P R M	S T P O M	S Q A	O C M	O P F	O P D
Measurements are made and used to determine the status of the software process improvement activities.	PCM M1							R
Number of proposals submitted for each process area	PCM M1							R
Number of proposals implemented for each process area	PCM M1							R
Number of proposals submitted for each project	PCM M1							R
Number of proposals submitted for each group	PCM M1							R
Number of proposals submitted for each department	PCM M1							R
Number of proposals submitted for each project	PCM M1							R
Number and types of awards and recognitions received by each project	PCM M1							R
Number and types of awards and recognitions received by each group	PCM M1							R
Number and types of awards and recognitions received by each department	PCM M1							R
Response time for handling software process improvement proposals	PCM M1							R
Percentage of software process improvement proposals accepted per reporting period	PCM M1							R
Overall change activity	PCM M1							R
- number	PCM M1							R
- type	PCM M1							R
- size	PCM M1							R
Process measurements that relate to indicators of the customer's satisfaction	PCM M1							R
Goals for the performance of the organization's software processes	PCM M1							R
- effectiveness	PCM M1							R
- quality	PCM M1							R
- productivity	PCM M1							R
Actual performance of the organization's software processes	PCM M1							R
- effectiveness	PCM M1							R
- quality	PCM M1							R
- productivity	PCM M1							R
Goals for the performance of each project's software processes	PCM M1							R
- effectiveness	PCM M1							R
- quality	PCM M1							R
- productivity	PCM M1							R
Actual performance of each project's software processes	PCM M1							R
- effectiveness	PCM M1							R
- quality	PCM M1							R
- productivity	PCM M1							R

[illegible]

**Page 48**

# **CMM v1.1 Measurement Map**

## **Part 3**

### **The Software Process Database**

<b>Topic</b>	<b>Page</b>
Data Storage & Use	50

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2			Level 3			Lvl 4			Level 5		
			P R M	P T O	S S Q C A M	O P P F	O P P T	I P I P	P P P P	Q Q Q Q	P P P P	D D D D	T T T T	
<b>Data Storage &amp; Use</b> There is a software process database The database is coordinated at the organizational level. The database is established. The database is maintained. The database is managed and controlled. User access to the database is controlled to ensure completeness, integrity, and accuracy of the data. Access is limited to those who have a need to enter, change, view, analyze, or extract data.	OPF A4 OPF A4 OPD A5 OPD A5 OPD A5.3 OPD A5.4 OPD A5.4		R R R R R R											
Sensitive data are protected. Access to sensitive data is appropriately controlled. The individuals who develop a project's defined software process receive training in using the software process database.	OPD A5.4 OPD A5.4 IM Ab2	Rules for determining "need" should be made explicit, else this statement has little operational content. Limiting access implies that an access authorization list be maintained, some form of read-only access mechanism be used, and authorization be checked before change access is granted. The CMM would be more helpful if it mentioned these issues.		R R E										
The organization's standard software process provides the ability to define and aggregate a standard set of process measurements from the projects at the organization level. The standard software process documents the product data to be collected. The standard software process documents the process data to be collected.	OPD C1.1 OPD A2.2 OPD A2.2			R T T										
Data entered into the database is reviewed to insure integrity of database contents. The database contains or references the actual measurement data. The database contains the data needed to understand and interpret the measurement data. The database contains the data needed to assess the measurement data for reasonableness and applicability. Each project provides appropriate software planning data for storage. Each project provides appropriate software replanning data for storage. Each project provides appropriate measured data for storage. Each project collects and stores project measurement data in the database. Each project collects and stores process measurement data in the database. Each project's software process measurements that relate to the organization's standard software process are collected uniformly across all projects. The organization's software process database is used for planning and estimating. The database is used as a source of data to estimate, plan, track, and replan projects.	OPD A5.2 OPD A5.2 OPD A5.2 IM A5.3 IM A5.3 IM A5.3 IM C1 QPM A4.9 QPM A4.5 IM A5 IM A5.1			R R R R R R R R R R							T T T			
Data from similar projects are used when possible. Parameter values used for estimating are compared to those of other projects. Similarities and differences to other projects are assessed. Similarities and differences to other projects are recorded. Rationales for similarities and differences between parameter values are recorded. The reasoning used to judge the credibility of the project's estimates is recorded.	IM A5.1 IM A5.2 IM A5.2 IM A5.2 IM A5.2 IM A5.2	The SEI cost-estimating checklists can be helpful here [Park 95].												

Measures and things to be measured are shown in bold face.

R = Required I = Implied T = Typical E = Example X = Implied by Example



[illegible]

**R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example**

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2		Level 3		Level 4	Level 5
			P R M	S T P O M	S C C P F A	S S P D M	O O P E G	Q P P R M
Parameter values used to derive estimates for size, effort, cost, schedule, and use of critical computer resources	IM A5.2					R		
Updated parameter values Associated information needed to reconstruct estimates, assess reasonableness, and derive estimates for new work Similarities and differences to other projects Rationales for similarities and differences between parameter values The reasoning used to judge the credibility of the project's estimates Each project's software process data, as summarized in its process performance baseline	IM A7.4 IM A7.4 IM A5.3  IM A5.2 IM A5.2 IM A5.2 QPM A7.1	The SEI cost estimating checklists can be helpful here.				T I E  R R R		
Cost of software process development Cost of software process improvement Schedule for software process development Schedule for software process improvement Productivity of software process development Productivity of software process improvement	PCM A9.3 PCM A9.3 PCM A9.3 PCM A9.3 PCM A9.3 PCM A9.3	?? This seems like an excessive requirement. ?? This seems like an excessive requirement.					T	
								E E E E E E

Measures and things to be measured are shown in bold face.

R = Required I = Implied T = Typical E = Example X = Implied by Example

## References

- [Fenton 91] Fenton, Norman E. *Software Metrics: A Rigorous Approach*. London: Chapman & Hall, 1991.
- [Park 95] Park, Robert E. *Checklists and Criteria for Evaluating the Cost and Schedule Estimating Capabilities of Software Organizations* (CMU/SEI-95-SR-05, ADA 293 299). Pittsburgh, Pa.: Software Engineering Institute, Carnegie Mellon University, January 1995.
- [Paulk 93a] Paulk, Mark C. et al. *Capability Maturity Model for Software, Version 1.1* (CMU/SEI-93-TR-24, ADA 263 403). Pittsburgh, Pa.: Software Engineering Institute, Carnegie Mellon University, February 1993.
- [Paulk 93b] Paulk, Mark C. et al. *Key Practices of the Capability Maturity Model, Version 1.1* (CMU/SEI-93-TR-25, ADA 263 432). Pittsburgh, Pa.: Software Engineering Institute, Carnegie Mellon University, February 1993.
- [Paulk 95] Paulk, Mark C.; Weber, Charles V.; Curtis, Bill; Chrissis, Mary Beth; et al. *The Capability Maturity Model: Guidelines for Improving the Software Process*. Reading, Ma: Addison-Wesley, 1995.
- [Wheeler 92] Wheeler, Donald J. & Chambers, David S. *Understanding Statistical Process Control*. Knoxville, Tenn.: SPC Press, 1992.
- [Wheeler 95] Wheeler, Donald J. *Advanced Topics in Statistical Process Control*. Knoxville, Tenn.: SPC Press, 1995.

## REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION <b>Unclassified</b>			1b. RESTRICTIVE MARKINGS <b>None</b>		
2a. SECURITY CLASSIFICATION AUTHORITY <b>N/A</b>			3. DISTRIBUTION/AVAILABILITY OF REPORT <b>Approved for Public Release Distribution Unlimited</b>		
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE <b>N/A</b>					
4. PERFORMING ORGANIZATION REPORT NUMBER(S) <b>CMU/SEI-96-SR-003</b>			5. MONITORING ORGANIZATION REPORT NUMBER(S)		
6a. NAME OF PERFORMING ORGANIZATION <b>Software Engineering Institute</b>		6b. OFFICE SYMBOL (if applicable) <b>SEI</b>	7a. NAME OF MONITORING ORGANIZATION <b>SEI Joint Program Office</b>		
6c. ADDRESS (city, state, and zip code) <b>Carnegie Mellon University Pittsburgh PA 15213</b>			7b. ADDRESS (city, state, and zip code) <b>HQ ESC/AXS 5 Eglin Street Hanscom AFB, MA 01731-2116</b>		
8a. NAME OF FUNDING/ SPONSORING ORGANIZATION <b>SEI Joint Program Office</b>		8b. OFFICE SYMBOL (if applicable) <b>ESC/AXS</b>	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER <b>F19628-95-C-0003</b>		
8c. ADDRESS (city, state, and zip code) <b>Carnegie Mellon University Pittsburgh PA 15213</b>			10. SOURCE OF FUNDING NOS.		
			PROGRAM ELEMENT NO <b>63756E</b>	PROJECT NO. <b>N/A</b>	TASK NO <b>N/A</b>
			WORK UNIT NO. <b>N/A</b>		
11. TITLE (Include Security Classification) <b>CMM Version 1.1 Measurement Map</b>					
12. PERSONAL AUTHOR(S) <b>Robert E. Park</b>					
13a. TYPE OF REPORT <b>Final</b>		13b. TIME COVERED <b>FROM TO</b>		14. DATE OF REPORT (year, month, day) <b>October 1996</b>	
15. PAGE COUNT <b>53</b>					
16. SUPPLEMENTARY NOTATION					
17. COSATI CODES			18. SUBJECT TERMS (continue on reverse of necessary and identify by block number) <b>Capability Maturity Model for Software (CMM), key process areas, measures, measurement</b>		
FIELD	GROUP	SUB. GR.			
19. ABSTRACT (continue on reverse if necessary and identify by block number)  This report identifies and tabulates all references to software measures and measurement activities that appear in Version 1.1 of the Capability Maturity Model <sup>sm</sup> for Software (CMM <sup>sm</sup> ). Each reference is listed in a structured format, and the results are sorted into topic areas in a way that is designed to help organizations plan the evolution of their measurement activities across the key process areas of the CMM. Where the CMM's guidance is unclear or incomplete, opportunities for improving the CMM are noted and explained.					
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT <b>UNCLASSIFIED/UNLIMITED <input checked="" type="checkbox"/> SAME AS RPT <input type="checkbox"/> DTIC USERS <input checked="" type="checkbox"/></b>				21. ABSTRACT SECURITY CLASSIFICATION <b>Unclassified, Unlimited Distribution</b>	
22a. NAME OF RESPONSIBLE INDIVIDUAL <b>Thomas R. Miller, Lt Col, USAF</b>				22b. TELEPHONE NUMBER (incl. area code) <b>(412) 268-7631</b>	22c. OFFICE SYMBOL <b>ESC/AXS (SEI)</b>

ABSTRACT — continued from page one  
block 19